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Ultrasonography of the abdominal wall before and after laparotomy in cows

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Abstract: The ultrasonographic appearance of the normal abdominal wall in the flank region was investigated before and after exploratory laparotomy in five cows (group A). The results were compared with those after surgical correction of left displaced abomasum in 10 cows (group B) and of caecal dilatation in another 10 cows (group C). We hypothesized that in group C and group B, wound healing would be impaired because of the higher risk of complications compared to group A. A 10.0 MHz linear transducer was used to examine the abdominal wall immediately before exploratory laparotomy and for 10 days (groups B, C) or 30 days (group A) postoperatively. The thickness of the individual layers of the abdominal wall was determined. The skin and the individual muscle layers could be well differentiated via ultrasonography in all the cows preoperatively. In group A, the total thickness of the abdominal wall ranged from 2.80 to 3.40 cm; the skin and the subcutaneous tissues were 0.60 to 0.80 cm, the external abdominal oblique muscle 0.50 to 0.70 cm, the internal abdominal oblique muscle 0.50 to 0.70 cm, the transverse abdominal muscle 0.50 to 0.75 cm, and the transverse fascia and peritoneum were 0.20 to 0.30 cm. Groups B and C had similar findings. There was no significant difference in the course of healing, the thickness of the abdominal wall or thickness of the individual layers during healing among the three groups of cows. Features of healing included subcutaneous emphysema in 19 cows, seroma in 19 and haematoma in 2 cows. However, the occurrence of these events did not differ significantly among the three groups. Ultrasonographic examination of the wound on day 10 postoperatively was unremarkable in 24 cows. A seroma was still present on day 15 postoperatively in one cow of group B.
Zusammenfassung: In der vorliegenden Untersuchung werden das ultrasonographische Erscheinungsbild der gesunden Bauchwand im Bereich der Flanke sowie die Befunde bei einer ungestörten Heilung im Anschluss an eine Probelaparotomie von 5 Kühen (Gruppe A) beschrieben. Die gewonnenen Befunde werden mit denen von je 10 Kühen verglichen, die wegen linksseitiger Labmagenverlagerung (Gruppe B) bzw. Blinddarmdilatation (Gruppe C) operiert wurden. Die Ultraschalluntersuchung der Bauchwand erfolgte mit einem 10.0-MHz-Linearschallkopf unmittelbar vor der Laparotomie und während 10 (Gruppen B und C) bis 30 Tagen (Gruppe A) danach. Die Dicken der einzelnen Bauchwandschichten wurden mit den elektronischen Cursormarken gemessen. Präoperativ konnten die einzelnen Schichten der Haut und der Muskulatur ultrasonographisch bei allen Kühen gut von einander differenziert werden. Bei den Kontrollkühen lag die Gesamtdicke der Bauchwand zwischen 2.80 und 3.40 cm. Davon entfielen 0.60 bis 0.80 cm auf die Haut und Unterhaut, 0.50 bis 0.70 cm auf den M. obliquus externus, 0.50 bis 0.70 cm auf den M. obliquus internus, 0.50 bis 0.75 cm auf den M. transversus und 0.20 bis 0.30 cm auf die Fascia transversa und das Peritoneum. Ähnliche Befunde wurden bei den Kühen der Gruppen B und C erhoben. Der Heilungsverlauf der 3 Gruppen unterschied sich nicht signifikant. Bei den Kühen aller 3 Gruppen änderte sich die Bauchwanddicke und die Dicke der einzelnen Bauchwandschichten im Verlauf der 5- bzw. 30-tägigen Untersuchungsperiode nicht signifikant. Bei insgesamt 19 Kühen traten Emphyseme, bei 19 Kühen Serome und bei 2 Kühen Hämatome auf. Das Auftreten dieser Veränderungen unterschied sich zwischen den 3 Gruppen nicht signifikant. Am Tag 10 stellte sich die Wunde ultrasonographisch bei 24 von 25 Kühen unauffällig dar. Bei einer Kuh der Gruppe B war bis zum Tag 15 noch ein Serom zu sehen.

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Ultrasonography of the abdominal wall before and after laparotomy in cows

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Summary

The ultrasonographic appearance of the normal abdominal wall in the flank region was investigated before and after exploratory laparotomy in five cows (group A). The results were compared with those after surgical correction of left displaced abomasum in 10 cows (group B) and of caecal dilatation in another 10 cows (group C). We hypothesized that in group C and group B, wound healing would be impaired because of the higher risk of comlications compared to group A. A 10.0 MHz linear transducer was used to examine the abdominal wall immediately before exploratory laparotomy and for 10 days (groups B, C) or 30 days (group A) postoperatively. The thickness of the individual layers of the abdominal wall was determined. The skin and the individual muscle layers could be well differentiated via ultrasonography in all the cows preoperatively. In group A, the total thickness of the abdominal wall ranged from 2.80 to 3.40 cm; the skin and the subcutaneous tissues were 0.60 to 0.80 cm, the external abdominal oblique muscle 0.50 to 0.70 cm, the internal abdominal oblique muscle 0.50 to 0.70 cm, the transverse abdominal muscle 0.50 to 0.75 cm, and the transverse fascia and peritoneum were 0.20 to 0.30 cm. Groups B and C had similar findings. There was no significant difference in the course of healing, the thickness of the abdominal wall or thickness of the individual layers during healing among the three groups of cows. Features of healing included subcutaneous emphysema in 19 cows, seroma in 19 and haematoma in 2 cows. However, the occurrence of these events did not differ significantly among the three groups. Ultrasonographic examination of the wound on day 10 postoperatively was unremarkable in 24 cows. A seroma was still present on day 15 postoperatively in one cow of group B.

Keywords: cattle, ultrasonography, abdominal wall, laparotomy

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In der vorliegenden Untersuchung werden das ultrasonographische Erscheinungsbild der gesunden Bauchwand im Bereich der Flanke sowie die Befunde bei einer ungestörten Heilung im Anschluss an eine Probelaparotomie von 5 Kühen (Gruppe A) beschrieben. Die gewonnenen Befunde werden mit

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Schlüsselwörter: Rind, Sonographie, Bauchwand, Laparotomie

Introduction

Delayed wound healing after laparotomy is a relatively common occurrence in cattle. It may be attributable to oedema, herniation, dehiscence, localised infection or the formation of a fistula, seroma, haematoma or abscess (McIlwraith, 1978; Becker, 1985; Wilson et al., 1989; Georgiadis, 1995). Generally, aseptic processes such as emphysema, haematoma and seroma are differentiated from septic processes, which include infection and abscess formation (Trede et al., 1982). In cattle, both septic and aseptic processes are often involved in delayed incisional healing after laparotomy (Becker, 1985). The classical method of wound assessment includes a clinical examination, focusing on evaluation of the general condition, behaviour, appetite and rectal temperature of the patient, as well as visual inspection and palpation of the incision and centesis of lesions. Visual inspection identifies swelling, secretion and dehiscence, and palpation is used to determine the consistency, temperature and sensitivity of the lesion. However, in many cases, these tools are inadequate for

determining the definitive problem, particularly with regard to infection. Studies in people (Kenney, 1998; Krombach et al., 2001), horses (Wilson et al., 1989) and cattle (Bienek and Grunert, 1997) have shown that ultrasonography can be used to objectively evaluate wound healing. Therefore, ultrasonography has become the method of choice for assessment of healing of laparotomy incisions (Wilson et al., 1989; Bienek and Grunert, 1997). High-frequency linear transducers provide good images of the abdominal wall. A number of studies have described the ultrasonographic appearance of normal musculature (Harcke et al., 1988; Bonnaire, 1991), emphysema (Furtschegger et al., 1990), incisional seroma (Eichhorn et al., 1987; Heyder, 1992), incisional oedema (Rapf et al., 1986) and infection of the incision (Furtschegger et al., 1990; Bonnaire, 1991; Bienek and Grunert, 1997). The ultrasonographic findings after caesarian section in 20 cows have also been reported (Bienek and Grunert, 1997). The goal of the present study was to describe the ultrasonographic appearance of the normal abdominal wall of the flank and the ultrasonographic findings during normal healing of a laparotomy incision in five cows. These ultrasonographic findings were compared with those of incisional healing after right-flank laparotomy and omentopexy to correct left displacement of the abomasum in 10 cows and caecal dilatation with typhlotomy in another 10 cows.

Animals, Material and Methods

Animals and clinical examination

The study involved healthy cows (group A) destined for slaughter (controls) and cows with a left displaced abomasum (group B) or caecal dilatation (group C) that had been referred to the clinic. Group A consisted of 5 healthy cows (3 Swiss Braunvieh, one Holstein Friesian and one Simmental cow, aged 3 to 5 years). Group B consisted of 10 cows with a left displaced abomasum (7 Simmental/Red Holstein Crossbreeds and 3 Holstein-Friesian cows, aged 2.5 to 9 years). Group C consisted of 10 cows with caecal dilatation (6 Swiss Braunvieh and 4 Simmental cows aged 2.8 to 10 years).

All the cows underwent a thorough clinical examination as described by Rosenberger (1979) before surgery and ultrasonography. The incisions were inspected and palpated postoperatively for swelling, discharge, dehiscence and pain once daily. The study protocol was approved by the Animal Care Committe of the Canton of Zurich, Switzerland.

Laparotomy in control cows (group A)

The surgical procedure in cows of all 3 groups has been described in detail by Gorber (2009). A standing right flank laparotomy was carried out in all the cows by the same surgeon. After clipping, the surgical site was scrubbed three times with chlorhexidine soap (Hibiscrub, Globopharm, Egg) followed by rinsing and drying off the surgical field. After that, 70 per cent ethanol solution was applied on the skin. Proximal paravertebral local anaesthesia was carried out using 150 ml of 2 per cent lidocaine (Lidocain-Hyaluronidase 2 %, Streuli, Uznach). A 21- to 23-cm (21.8 ± 0.8 cm) incision was made in the skin 10 cm caudal to the last rib, starting approximately 10 cm ventral to the transverse processes of the lumbar vertebrae, and the subcutaneous tissue and muscle layers were cut in a vertical direction. The abdomen was explored and the incision closed. The peritoneum, fascia and transverse muscle were sutured using a no. 2 absorbable braided suture material (Polysorb^{TM}, Syneture, USA) in a simple continuous suture pattern. The internal and external oblique muscles were each sutured separately using the same suture material in a simple continuous suture pattern. To prevent seroma formation, every second bite in the internal and external abdominal oblique muscles and subcutis included the adjacent deep layer. The subcutaneous tissues were closed using no. 0 absorbable suture material in a modified, non everting horizontal mattress pattern. The skin was closed with no. 1 non-absorbable suture material (Supramid, B. Braun, Melsungen, Germany) in a Ford continuous interlocking suture pattern. Postoperatively, the cows received 9 x 10^6 IU of procaine penicillin (Benzylpenicillinum procainum, Intervet, Zurich), intramuscularly, three times daily for 3 days, 500 mg of flunixin meglumine (Finadyne, Berna, Berne), intramuscularly, once daily for 3 days and 10 litres of sodium chloride and glucose solution (50 g glucose and 9 g NaCl/litre) daily via an indwelling intravenous catheter for 3 days. The skin sutures were removed on day 10 postoperatively. Thirty days later, the cows were slaughtered at the University abattoir and the incisions and internal organs were examined macroscopically.

Laparotomy in cows with left abomasal displacement (group B)

The incision started 10 - 15 cm ventral of the lumbar vertebral processes and was oriented parallel and caudal to the last rib. The length of the incision in this group was 16.0 to 24.1 cm (18.7 ± 2.5 cm). After exploration of the abdominal cavity, the gas in the abomasum was released manually using a 12 ga needle attached to a 150 cm long sterile rubber tubing and the displaced abomasum was repositioned. An omentopexy was done by fixing the greater omentum in the ventral angle of the incision approximately 10 cm caudal to the pylorus, and suturing this area to the ventral angle of the incision. Closure of the incision and postoperative care were the same as for the controls. Concurrent diseases were treated accordingly. The cows were discharged five to 7 days postoperatively, and a

clinical and ultrasonographic examination and suture removal were done 10 days postoperatively. The surgery procedure did not differ among surgeons and the surgery time was 35 to 60 minutes. No major break in asepsis nor any major complication occurred during surgery.

Laparotomy in cows with caecal dilatation (group C)

In this groop, the paravertebral local anaesthesia was extended caudally by blocking the third lumbar nerve. The incision was situated in the caudal part of the lumbar fossa. It ran from caudodorsal to cranioventral and was 21.5 to 25.7 cm (24.0 ± 1.5 cm) in length. After placing a protective drape (wound edge protector-3M™, Steri-Drape™, 3 M Schweiz, Rüschlikon) into the incision the caecum was exteriorised and a three to five cm incision was made with a scalpel blade in the tip of the caecum to empty it. The incision was closed using no. 2 absorbable suture material (Biosyn 2.0, Monofilament Glycomer, USSC Medical, USA) in a Kürschner suture followed by a Cushing suture and then cleaned with an antiseptic solution (Betadine Solution, Mundipharma Medical Company, Basle, 10 ml diluted in 1 Liter Ringer's solution) and rinsed with saline solution. The caecum was then repositioned with its tip facing caudally within the abdominal cavity. In cows with poor peristalsis, 10 ml neostigmine (Konstigmin, Vetoquinol, Ittigen) were administered topically over the caecum. After waiting five minutes, the caecum was exteriorised again and emptied the same way if required. Suturing, postoperative care, discharge from the clinic and suture removal were the same as in group B. The surgery procedure did not differ among surgeons and the surgery time was 35 to 60 minutes. No major break in asepsis nor any major complication occurred during surgery.

Ultrasonographic examination

Ultrasonographic examinations were done with a real-time scanner (EUB 8500, Hitachi Medical Systems, Zug) and a 10.0 MHz linear transducer. The postoperative ultrasonographic examinations on day 10 in groups B and C were carried out using a portable ultrasound machine (Tringa Linear, Esaote Pie-Medical, Provet, Lyssach) with a 5.0 MHz linear transducer.

The cows were examined via ultrasonography immediately before surgery. In the controls, further ultrasonographic examinations were carried out daily on days 1 to 10 and then every other day up to 30 days postoperatively. The cows in groups B and C were examined daily from days 1 to 5 postoperatively. They were re-examined after discharge on day 10 postoperatively.

The ultrasonographic examination included assessment of the abdominal wall at the surgical site. The appearance of the skin, subcutaneous tissues, external and internal abdominal oblique muscles, transverse muscle, transverse fascia and peritoneum were evaluated preoperatively. The thickness of

the entire abdominal wall and each of the individual layers were measured electronically using the two cursors on ultrasonograms in the freeze mode. These examination procedures were repeated postoperatively, with emphasis placed on the detection of abnormalities such as abnormal fluid accumulation and gross disruption of the muscle layers.

Statistical analysis

The Statistical analysis was performed by use of a statistics software program (StatView 5.1, SAS Institute, Wangen). Frequencies, means and standard deviations were calculated. Analysis of variance (ANOVA) for repeated measures and a paired t-test were used to analyse differences within groups between ultrasonographic measurements taken preoperatively and postoperatively up to day 10. Factorial ANOVA was used for differences between measurements from controls and those from groups B and C. A P-value <0.05 was considered statistically significant.

Results

Clinical findings

The general condition and demeanour remained normal throughout the study in the control cows, and were mildly to severely abnormal on the day of surgery (day 0) in the cows with left displaced abomasum and caecal dilatation but then normalized after few days. In many cows there was a mild postoperative swelling of the incisional area for 4 to 16 days postoperatively. Secretion of fluid, wound dehiscence or signs of infection did not occur in any of the cows. The incision healed by primary intention in 24 cows. One cow in group B had a larger seroma and oedema of the incisional site which resolved by day 16. The details of the clinical findings have been described by Gorber (2009).

Ultrasonographic findings immediately before surgery

The individual layers of the abdominal wall could be easily differentiated via ultrasonography in all the cows preoperatively (Fig. 1). The skin appeared as a hypoechoic structure immediately adjacent to the echoic subcutis. The internal and external abdominal oblique and transverse muscles could be differentiated because they were separated by a layer of echoic fascia, which surrounded each muscle. The muscle tissue was moderately echoic, and when viewed in longitudinal section, the muscle fibres appeared as numerous thin echoic lines arranged parallel to one another. The transverse fascia and peritoneum appeared as two adjacent echoic lines. The total thickness of the abdominal wall in the control cows was 2.80 to 3.40 cm (Tab. 1). The skin and subcutis were 0.60 to 0.80 cm, the external

abdominal oblique was 0.50 to 0.70 cm, the internal abdominal oblique 0.50 to 0.70 cm, the transverse muscle 0.50 to 0.75 cm and the transverse fascia and peritoneum were 0.20 to 0.30 cm. Similar results were obtained for cows in groups B and C. There were no significant differences among the three groups preoperatively ($P > 0.05$).

Ultrasonography after surgery

The course of healing and the thickness of the abdominal wall and its individual layers during the time after surgery did not differ significantly among the three groups (Tab. 1). Abnormalities during healing included mild emphysema in 19 cows, small seromas in 19 and a small haematoma in 2 cows (Tab. 2). There was no significant difference among the groups with regard to these lesions. Ten days postoperatively, ultrasonography revealed that the incisional site was unremarkable in 24 cows. A seroma was still present in one cow of group B but it became progressively smaller and was gone by day 15.

Localized emphysema occurred in 19 cows immediately after surgery and lasted four to five days. It appeared as echoic air inclusions with distal acoustic shadows or reverberation artifacts (Fig. 2).

The postoperative seromas seen in 19 cows were recorded on day 0 in 5 cows, day 1 in 9, day 2 in 10, day 3 in 7, day 4 in 6, day 5 in 5 and day 10 in one cows. They appeared as honeycomb-like structures containing pockets of hypoechoic fluid (Fig. 3). The seromas were in the subcutis in one cow, between the internal and external abdominal oblique muscles in 7, between the internal abdominal oblique and transverse muscles in 10 and between the transverse muscle and peritoneum in one cow. Their dimensions ranged from 2.0 to 5.0 cm in length, 0.3 to 1.8 cm in width and 0.28 to 0.60 cm in height.

A small haematoma (diameter, 0.4 to 1.2 cm) was seen in one cow in group B and one in group C. They appeared hypoechoic and, in contrast to the seromas, had small echoic areas of stippling along the edge. The haematoma in the cow in group B was seen on days 4 and 5, was located between the internal abdominal oblique and transverse muscles and was 0.60 x 1.00 cm. The haematoma in the cow in group C was seen on days 3 to 5, was located between the internal and external abdominal oblique muscles and was 0.40 x 1.20 cm.

Discussion

It was interesting that there was no significant difference in wound healing, assessed clinically and ultrasonographically, among the 3 groups although the cows had differing risks of wound contamination: exploratory laparotomy without incision of an organ; correction of left abomasal

displacement with abomasal centesis (low risk of contamination); and correction of caecal dilatation with incision of the caecum (high risk of contamination). Complications during wound healing were not encountered in any of the cows including those with a seroma between days 10 and 15 postoperatively. The favourable outcomes of our patients were attributable to an aseptic surgical technique as well as the use of atraumatic suture material. In addition, wound protection drapes were used during typhlotomy, so the contaminated procedure did not affect the body wall directly. Flushing before reposition of the caecum into the abdominal cavity reduced the amount of further contamination. The administration of a high dose of procaine penicillin every eight hours for three days postoperatively may also have influenced the outcome. The administration of postoperative antibiotics is a recommended procedure (Baxter, 1992; McIlwraith and Roberts, 1998).

Emphysema, which was seen in 19 cows in the present study, occurs after almost all laparotomies because of air trapped in the tissues during surgery. Extensive emphysema may be the result of a gap in the peritoneal suture line, which allows escape of intraabdominal air into the various layers of the abdominal wall. Such extensive emphysemas did not occur in the cows of the present study and thus air in the tissues deeper than the subcutis was rarely seen.

Seromas, which are accumulations of serous exudate in the incision, were also seen in 19 cows. Although strictly speaking seromas are considered a complication in wound healing, small seromas are not usually a major concern. Because of the length of the laparotomy incision and the number and thickness of the abdominal tissue layers, accumulation of intracellular and extracellular fluid, lymph and blood are to some extent unavoidable. Meticulous control of bleeding to prevent the accumulation of fluid and blood would have been ideal, but is not routinely carried out during laparotomy in cattle. Large seromas can result from irritation of the incisional area by foreign bodies, coagulation necrosis, fat necrosis, mass ligatures, tension on the suture line or infection (McIlwraith, 1982; Wilde and Wilde, 1993). Ultrasonographically, seromas are hypoechoic with distal acoustic enhancement and lateral zones of acoustic shadows (Eichhorn et al., 1987; Heyder, 1992). Disruption of the connective tissue and multiple pockets of fluid impart a honeycomb-like appearance to the seroma. Sonopalpation stirs up small pieces of hyperechoic concrement in the seroma (Kofler, 1997). Lymphoceles, which result from transection of lymphatic vessels, cannot be differentiated from seromas via ultrasonography. Cellular and tissue factors in the exudate also play a role in wound healing. In our study, the suture technique consisting of 5 separately adapted tissue layers may have prevented the formation of large seromas which predispose for dehiscence and/or infection.

Simmental/Red Holstein cows which are heavier muscled than Brown Swiss or Holstein Friesian cows and were often affected with caecal dilatation did not show different healing patterns in our

setting. In veterinary practice, a 3 layer suture is often applied which might not be as effective as a 5 layer technique, but detailed reports of wound healing complications in bovine surgery are scarce, maybe because follow up is not routinely done. Other causes of delayed wound healing, which include dehiscence, fistulation, localised infection and abscesses, were not encountered in our patients. This indicates that perioperative asepsis and surgical technique were appropriate. Results of this study provide reference variables which can be used to identify abnormal wound healing after laparotomy in cattle.

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Legend to figures

Figure 1: Ultrasonogram of the normal abdominal wall before laparotomy of a Braunvieh cow obtained from the right flank with a 10.0 MHz linear transducer. 1 Skin and subcutis, 2 External oblique muscle, 3 Internal oblique muscle, 4 Transverse muscle, 5 Fascia transversa and peritoneum.

Figure 2: Ultrasonogram of the abdominal wall showing emphysema in the subcutis after laparotomy in a Simmental cow with caecal dilatation. The examination was performed in the right flank using a 10.0 MHz linear transducer. The emphysema appears as echoic air inclusions with distal acustic shadows and reverberation artifacts. 1 Skin, 2 Subcutis, 3 Emphysema.

Figure 3: Ultrasonogram of the abdominal wall showing a seroma in the subcutis and the transverse muscle in a Holstein Friesian cow with left abdominal displacement after laparotomy. The examination was performed in the right flank using a 10.0 MHz linear transducer. The seroma appears as anechoic fluid in the subcutis and the transverse muscle. 1 Skin and subcutis, 2 External oblique muscle, 3 Internal oblique muscle, 4 Transverse muscle, 5 Fascia transversa and peritoneum.

359 Tab. 1: Emphysema, seroma and haematoma formation in control cows and cows with left abdominal displacement and caecal dilatation.

Abnormal findings	Controls (Group A) n = 5	Left abomasal displacement (Group B) n = 10	Caecal dilatation (Group C) n = 10
Emphysema	4 (80 %)	7 (70 %)	8 (80 %)
Seroma	3 (70 %)	8 (80 %)	8 (80 %)
Haematoma	0 (0 %)	1 (10 %)	1 (10 %)

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